UNIVERSIDAD ADOLFO IBÁÑEZ

Financial Feasibility of Storage Technologies in Electricity Systems

Empirical Evidence from Chile

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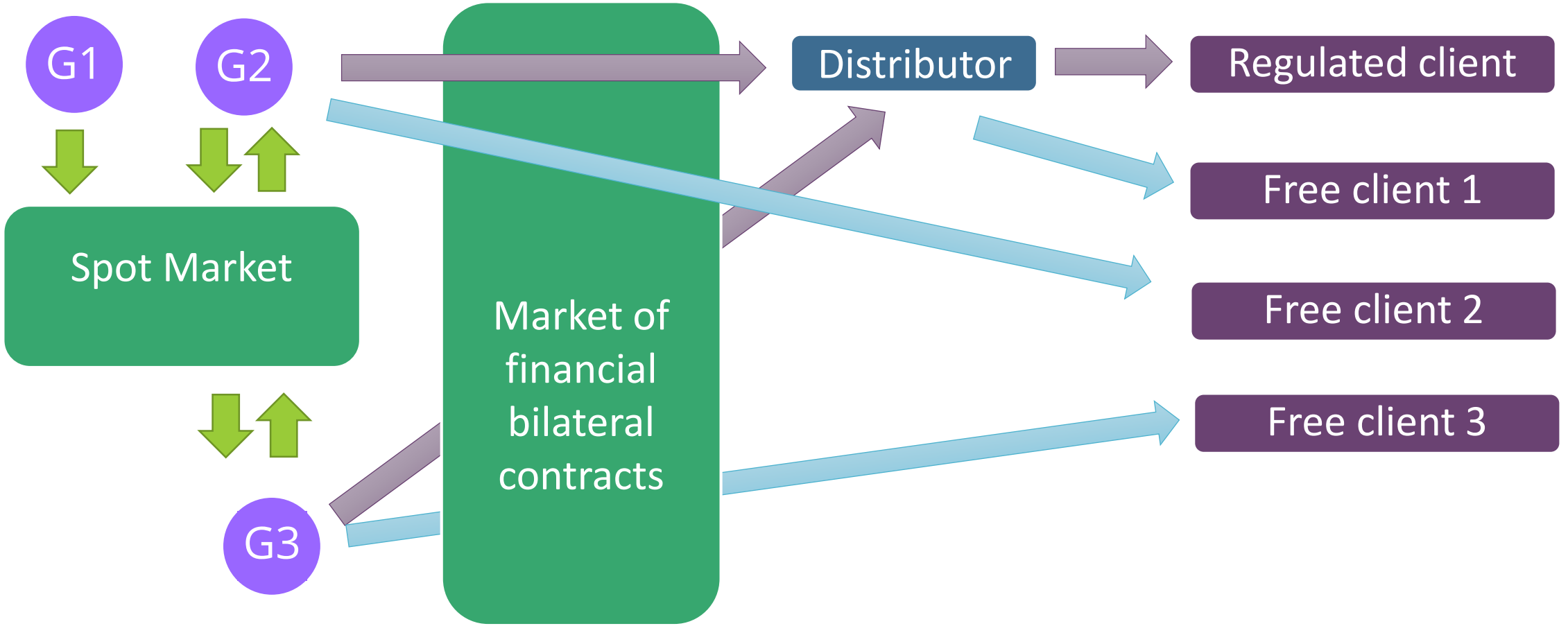
Presentation overview

- Introduction
- Methodology
- Results
- Conclusion

Chilean electric market

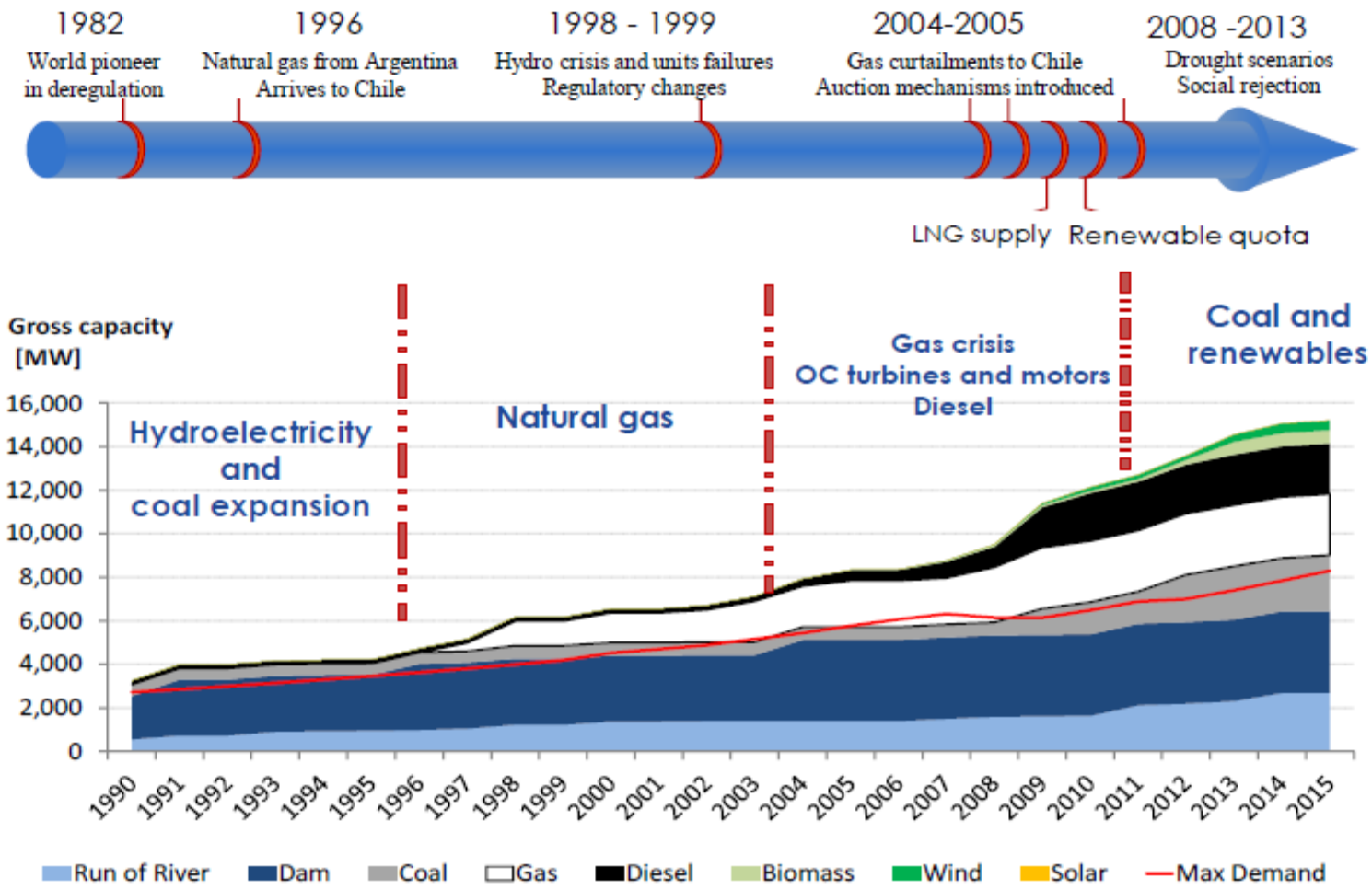


Purchase/sale to spot market

Regulated contract

Contract by direct negotiation

Evolution of Chilean Energy Matrix



Source: Solar Energy Research Center. 2016

Renewables and it challenges

- RPS scheme (Renewable Portfolio Standards) – 20% renewable energy target by 2025[1]
- Favorable solar radiation

Tecnología	Operación (1) [MW]	Construcción [MW]	RCA Aprobada (2) [MW]	En Calificación [MW]
Biomasa (3)	*463*	*0*	*469*	*79*
Eólica	*1.305*	*196*	*8.964*	*2.436*
Geotermia	*24*	*0*	*120*	*50*
Mini Hidro (4)	*450*	*47*	*805*	*114*
Solar - PV	*1.748*	*504*	*14.871*	*7.176*
Solar - CSP	*0*	*110*	*2.348*	*300*
Total	*3.990*	*857*	*27.577*	*10.155*

Source: Generadoras Chile. 2017

Challenges

- Reliability of supply
- Variability of supply
- Generation disconnected from demand
- Oversized transmission systems
- Frequency
- Voltage

1: Installed capacity of 22,000 MW approximately

Energy storage systems in Chile

- First energy storage system installed in 2009 (12 MW-3MWh Li-ion batteries)
- Second energy storage system installed in 2011 (20 MW-5MWh Li-ion batteries)
- Future projects
  - Espejo de Tarapacá (300 MW hydro pump storage system)
  - Cerro Dominador (110 MW CSP with 17.5 hours of energy storage)

Are Energy Storage Systems economically feasible in Chile?

Methodology

Annual benefits vs. costs

- Price arbitrage
- Diminishment in transmission losses
- Defer of transmission investment

Annual benefits

- Different spot price for each hour
- Less transmission losses

Annual costs

- Annuity of investment[2]
- O&M costs

2: To determine annual costs, a WACC of 6,67% was calculated

Methodology

- Price arbitrage

$$Max \sum_{t=1}^{8760} \pi(t)[P_c(t) - P_d(t)]\Delta t$$

- Diminishment in transmission losses

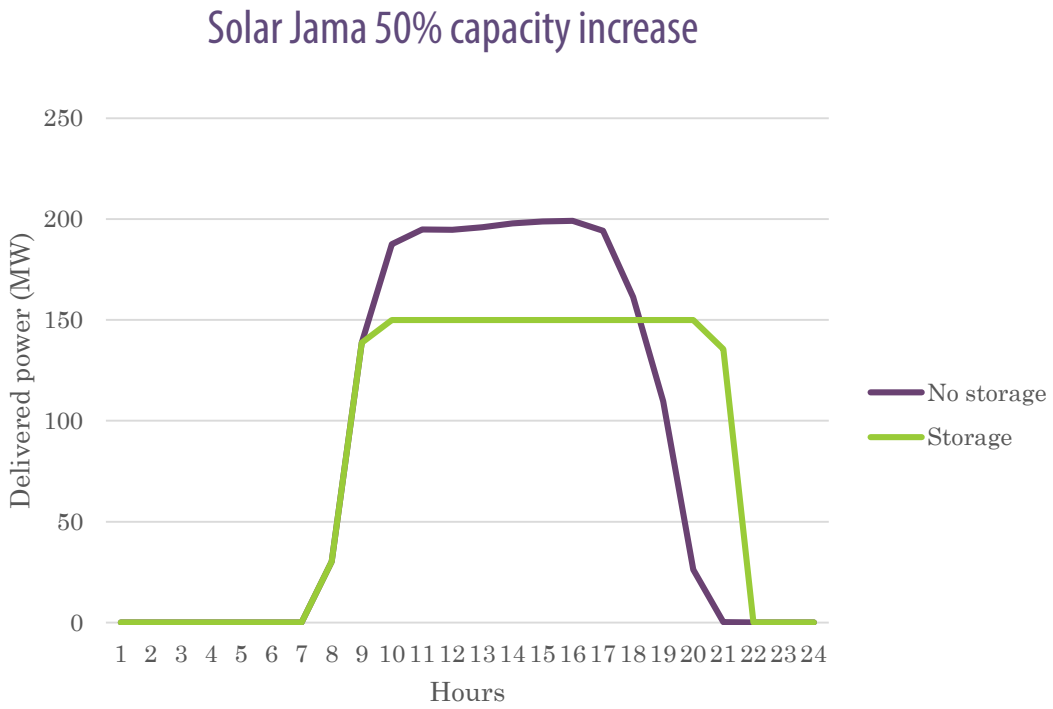
$$Min \sum_{n=1}^{8760} kP^2$$

$$\sum_{t=1}^{8760} \pi(t)\left[Loss_{without\ storage}(t) - Loss_{with\ storage}(t)\right]\Delta t + \sum_{t=1}^{8760} \pi(t)[P_c(t) - P_d(t)]\Delta t$$

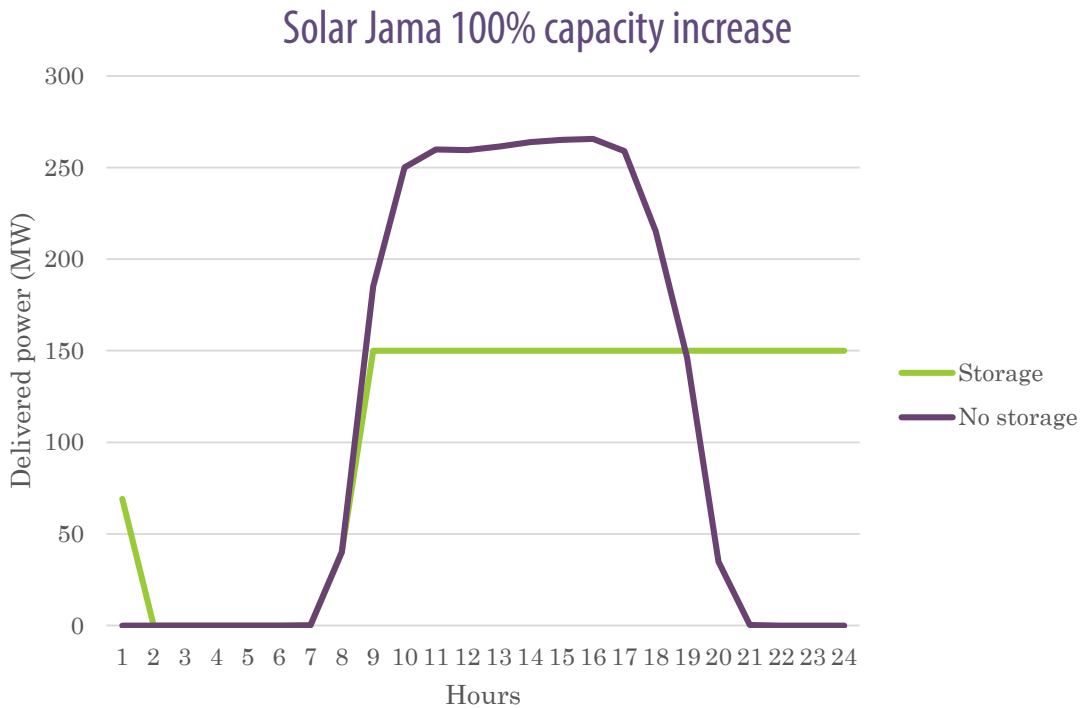
$$E(t) = (1-\sigma)E(t-\Delta t) + [\varphi\, P_c(t) - P_d(t)]\Delta t$$

Methodology

- Defer of transmission investment

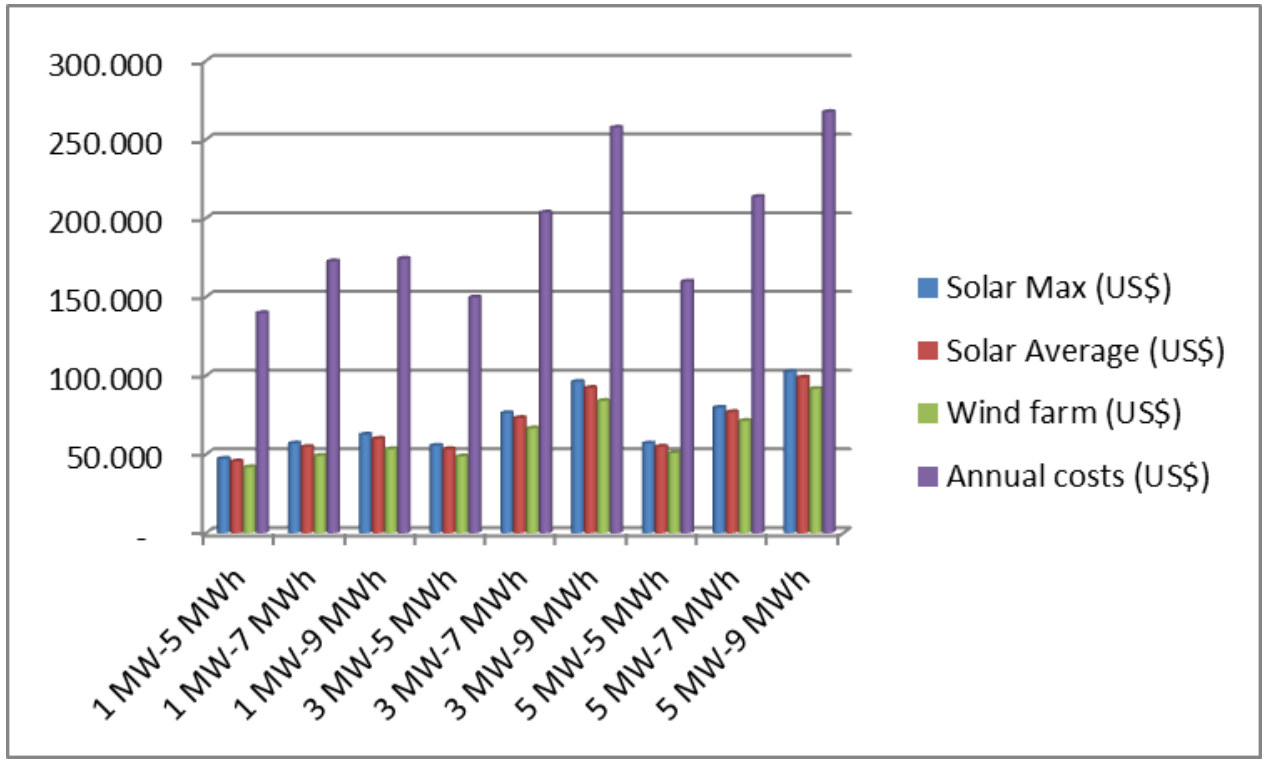


Source: Obtained from simulations

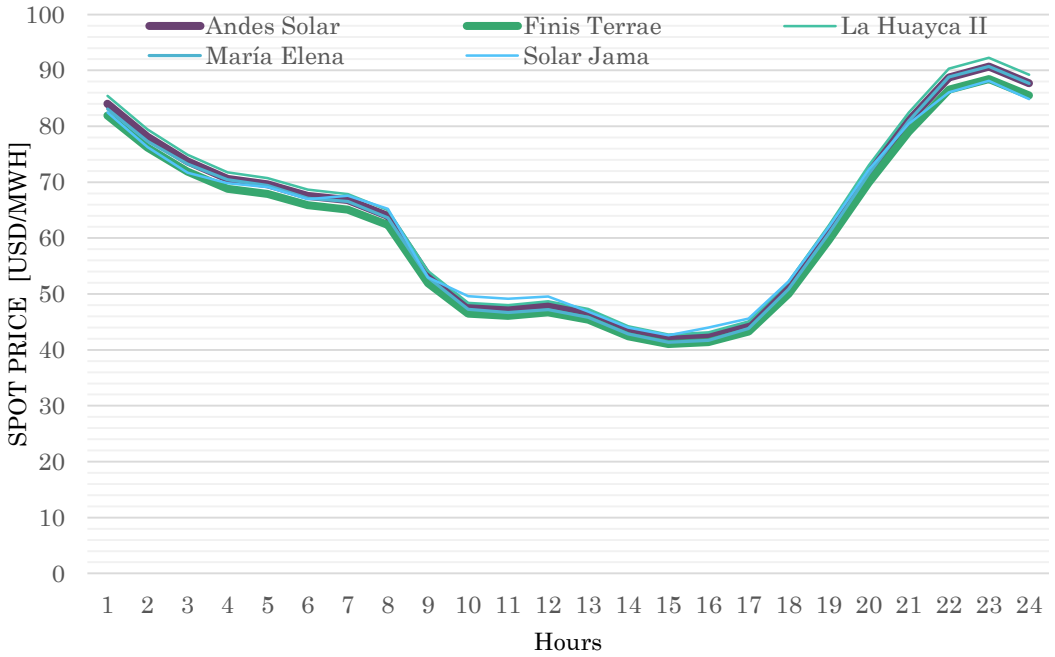


Source: Obtained from simulations

Results: Price arbitrage

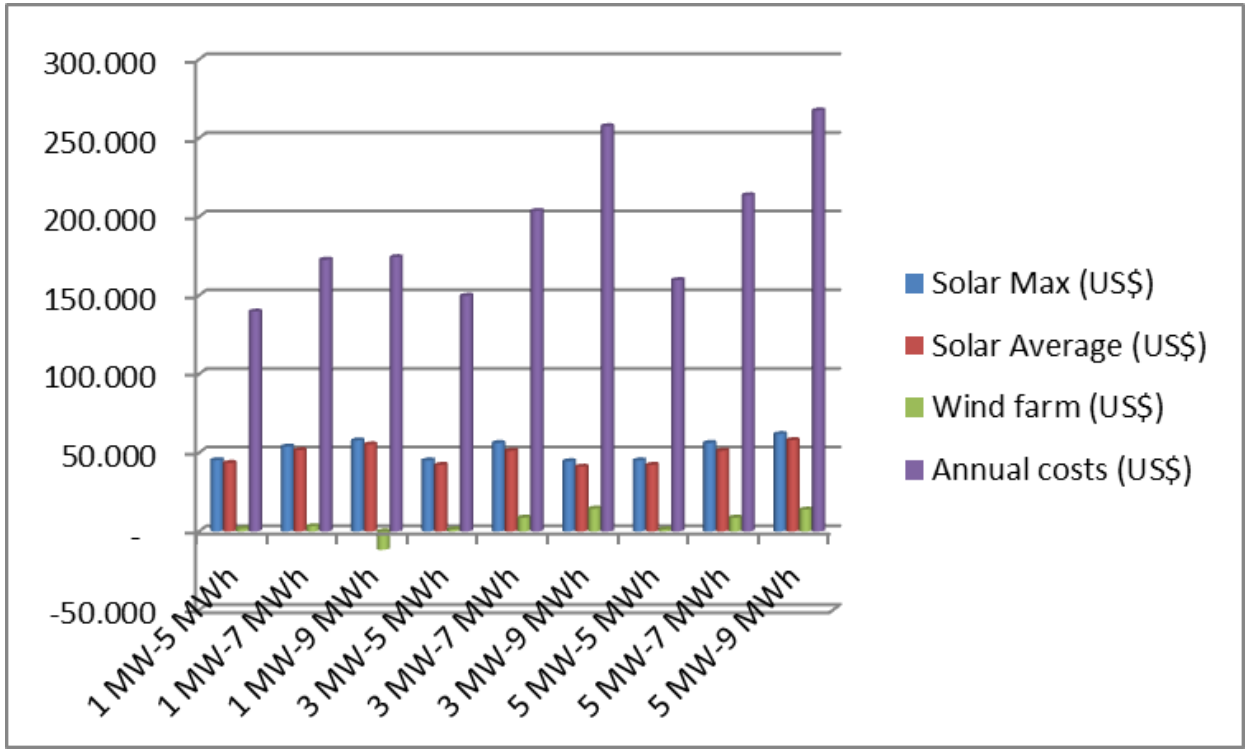


Source: Obtained from simulations

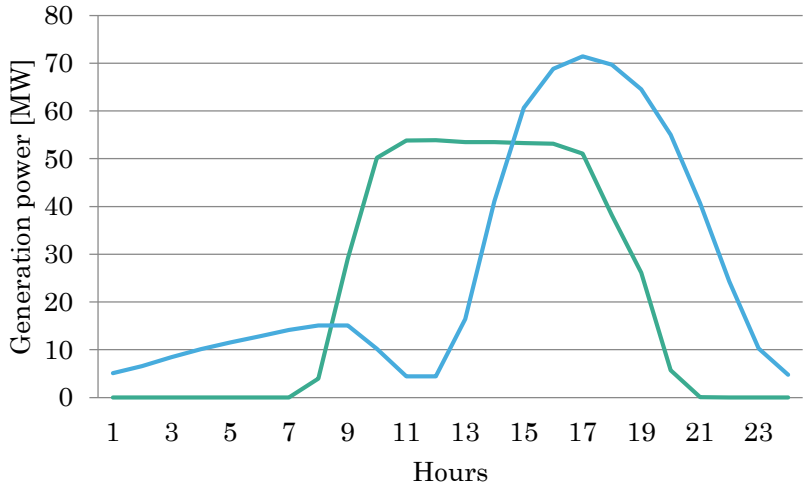


Source: CDEC – SING 2016

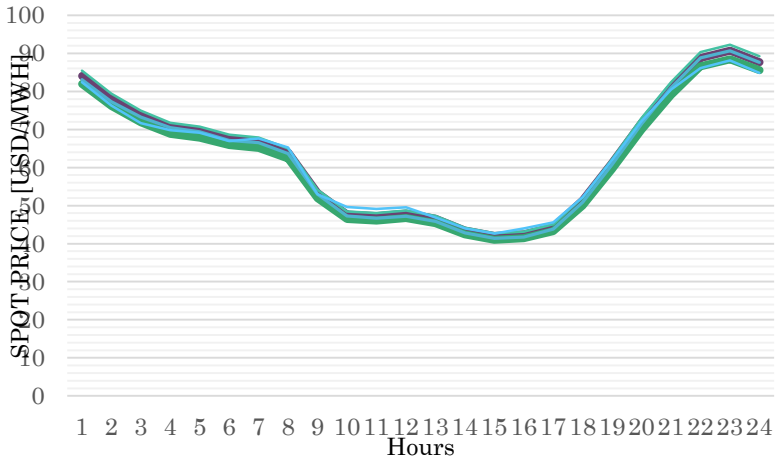
Results: Diminishment in transmission losses



Source: Obtained from simulations

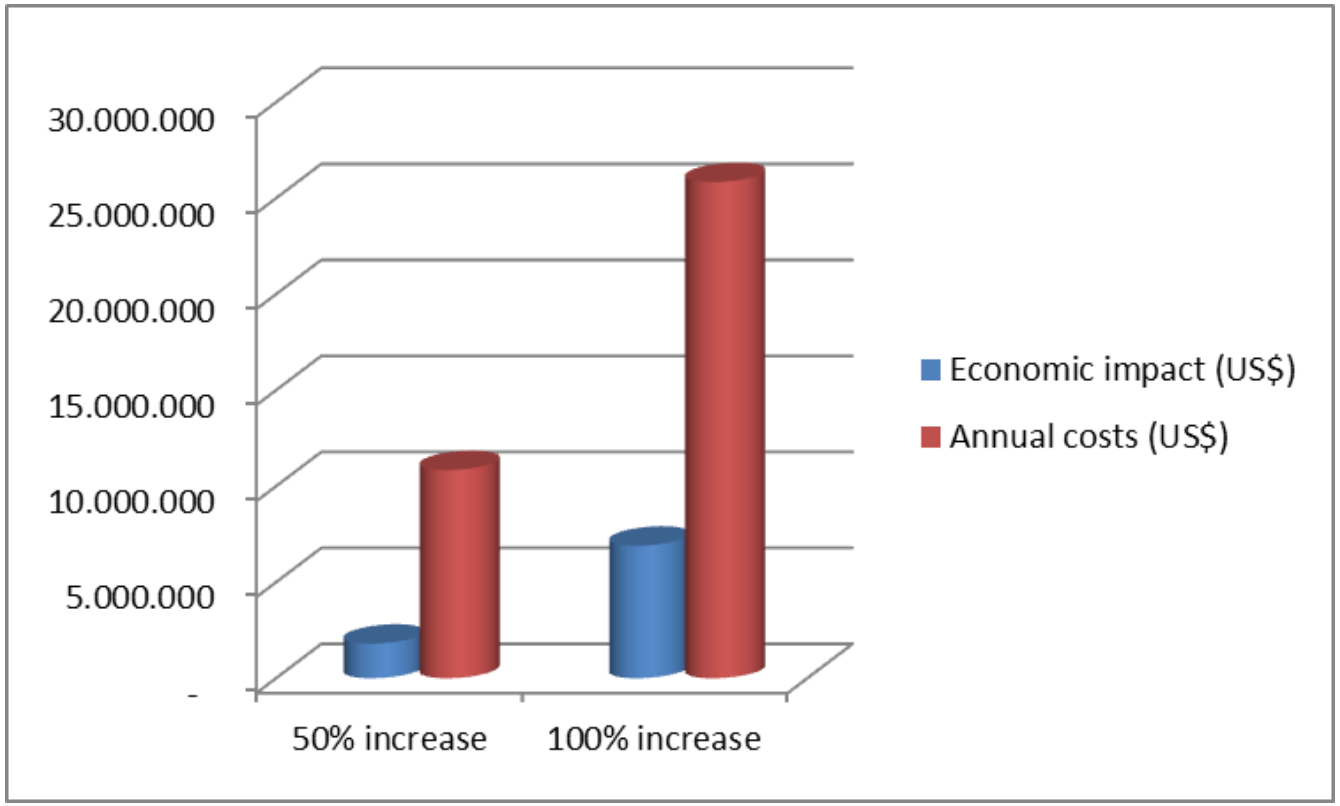


Source: CDEC – SING 2016

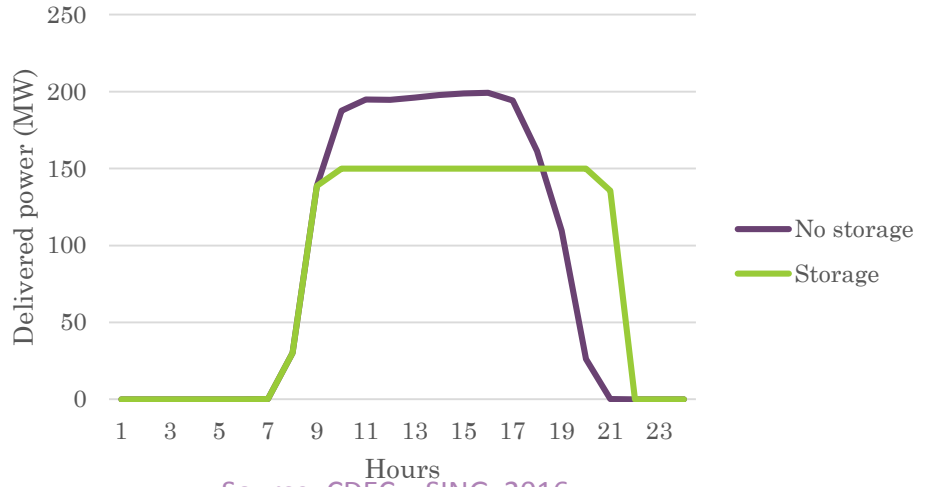


Source: CDEC – SING 2016

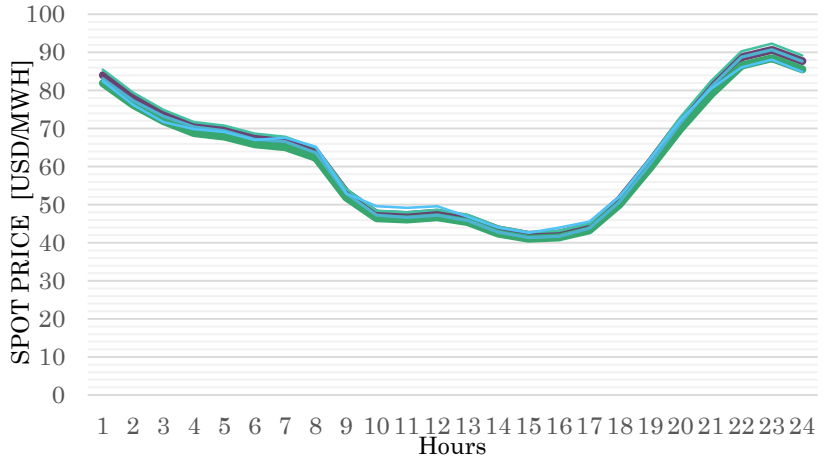
Results: Defer of transmission investment



Source: Obtained from simulations



Source: CDEC – SING 2016



Source: CDEC – SING 2016

Conclusion

- Energy storage is needed to connect supply and demand of renewables
- Energy storage is technically capable, but expensive
- Price arbitrage seems to be the best option
- Government subsidies needed
- Not recommended until price drops to around a third or the obtainable benefits increase